

NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE

		106FM02		
RESTRAINT 4000, ITEM 106 (1) LEFT (1) RIGHT ----- 0106-88936-11/12 (2)	1/1	Loss of fabric restraint.	END ITEM: Opening in restraint exposing bladder.	A. Design - 4000: The glove restraint hand portion is fabricated from 3.0 ounce dacron fabric which exhibits minimum tensile properties of 190 lbs. (warp) and 105 lbs. (fill). This material factor of safety is 18.8 (warp) and 10.4 (fill) times greater than required to support the predicted hand hoop load of 10.1 lbs. at 5.3 psid (maximum normal operating pressure). The finger restraint fabric is 3.0 ounce 1/8" grid dacron ripstop fabric. The fabric exhibits minimum tensile properties of 119 lbs. (warp) and 126 lbs. (fill). The material factor of safety is 14.1 (warp) and 15 (fill) times greater than the predicted hoop load of 8.4 lbs. at 5.3 psid (maximum normal operating pressure).
RESTRAINT PHASE VI, ITEM 106 (1) LEFT (1) RIGHT ----- 0106-812146-01/02 (2)		Separation of seam/fabric in restraint defective thread/cloth; abrasion; cut or tear in fabric.	GFE INTERFACE: Loading and abrading of bladder resulting in bladder failure. Suit gas leakage to ambient. Depletion of primary O2 supply and SOP. Rapid depressurizatio n of SSA beyond SOP makeup capability.	Seams are formed using size "E" polyester thread conforming to V-T-285-D type II class I. This thread/material combination yields minimum seam strengths of 84.0 lbs., 8.3 times greater than the hand hoop load at 5.3 psig.
----- 0106-812146-03/04 (2)			MISSION: Abort EVA.	Phase VI: The glove restraint hand portion is fabricated from 6.0 ounce dacron fabric which exhibits material safety factors of 29.7 (warp) and 24.8 (fill) against a predicted hand hoop load of 10.1 lbs. at 5.3 psig (maximum normal operating pressure). At 8.8 psig (maximum BTA operating pressure), the safety factor is 17.9 (warp) and 14.9 (fill).
			CREW/VEHICLE: Loss of crewmembers.	The finger restraint fabric is 3.0 ounce 1/8" grid dacron ripstop fabric. The fabric exhibits minimum tensile properties of 119 lbs (warp) and 126 lbs (fill). The material factor of safety is 14.1 (warp) and 15 (fill) times greater than the predicted hoop load of 8.4 lbs. at 5.3 psig (maximum normal operating pressure). At 8.8 psig (maximum BTA operating pressure), the safety factor is 8.5 (warp) and 9.0 (fill).
			TIME TO EFFECT /ACTIONS: Seconds.	Seams are formed using size "E" polyester thread conforming to V-T-285-D Type II Class I. This thread/material combination yields minimum seam strengths of 77 lbs., 7.6 times greater than the hand hoop load at 5.3 psig and 4.6 times greater than the hand hoop load at 8.8 psig.
			TIME AVAILABLE: N/A	In the axial direction, the glove restraint exhibited a minimum ultimate safety factor of 2.0 against the S/AD limit loads (5.3 psig) and at least 1.5 against the BTA limit loads (8.8 psig) during SSA Certification Testing.
			TIME REQUIRED: N/A	4000/Phase VI: The basic seam employed in the construction of non-flexural areas of the hand consists of a double row of joint stitching and a single row of top stitching. Finger and thumb flexural seams consist of two rows of stitching on each side of the digit, backtacked the entire seam length. All seams are formed with a type 301 lock stitch and are terminated by backtacking or by knotting and application of edge locking. Thread ends are seared in all cases.
			REDUNDANCY SCREENS: A-N/A B-N/A C-N/A	All pattern parts are cut with a hot knife to seal fabric ends and to prevent seam fraying. 6.5 ounce dacron fabric is utilized to reinforce seams and prevent seam pull out in high stress areas. Seam separation is precluded by multiple stitch rows on each seam, seam reinforcements, lock stitching and positive stitching termination.

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106FM02

The glove restraint/bladder is completely covered by a TMG which serves to protect fabric and seams from abrasion and cuts. The TMG will restrict glove bladder ballooning should a fabric/seam separation occur on the restraint.

B. Test -
 Acceptance:
 4000/Phase VI:
 Component - see inspection.

PDA Test -
 4000/Phase VI:
 The following test is conducted at the glove assembly level in accordance with ILC Document 0111-70028 (4000 glove) or 0111-710112 (Phase VI glove):
 1. Proof pressure test at 8.0 (+ 0.2 - 0.0) psig for five minutes to verify no structural damage.

Certification Test -
 4000:
 The glove restraint assembly was successfully tested (manned) during SSA certification to duplicate operational life (Ref. Cert Test Report, ILC Document 0111-77511).

The following usage, reflecting requirements of significance to the glove restraint assemblies, was documented during certification:

4000 Requirements	S/AD	Actual
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Glove Joint Cycles		
Flex/Ext (Fingers)	42,412	56,726
Wrist Joint Cycles		
Add/Abd	21,206	29,484
Flex/Ext	21,206	29,484
Rotations	21,206	29,484
Pressurized Hours	461	615
Pressurized Cycles	432	576
Don/Doff	144	192

The glove restraint assembly was successfully subjected to an ultimate pressure of 13.2 psig during SSA certification testing (Ref. ILC Document 0111-77511). This is 1.5 times the BTA maximum operating pressure of 8.8 psig. Recertification to 5.5 psi was by test and analysis (ref. ILC EM 84-1108). ECO-861-0037 Added teflon cloth protective sleeve to the 4000 series gloves (certified by similarity).

Phase VI:
 The glove restraint assembly was successfully tested (manned) during certification testing to duplicate operational usage (Ref. Certification Test Report for the Phase VI Glove, ILC Doc. 0111-712701). The following usage, reflecting requirements of significance to the glove restraint assembly, was documented during certification testing. The S/AD applies 229 hours in certification while the actual indicates 198 hours toward the Phase VI glove restraint in the Hamilton Sundstrand Limited Life Items list (EMU1-19-001).

NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE
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106FM02

Requirements	S/AD	Actual
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Glove Joint Cycles		
Flex/Ext (fingers)	45142	39169
Wrist Joint Cycles		
Add/Abd	17104	14830
Flex/Ext	12646	10830
Rotations	20112	17393
Pressurized Hours	229	198
Pressurized Cycle @ 4.3 psig	97	99
5.3 psig	37	63
6.6 psig	16	18
Don/Doff Cycles	49	49

The glove assembly was successfully subjected to an ultimate pressure of 13.2 psig during Certification Testing (Ref. ILC doc 0111-712701). This is 1.5 times the maximum BTA operating pressure based on 8.8 psig.

C. Inspection -
 4000/Phase VI:

Components and material manufactured to ILC requirements at an approved supplier are documented from procurement through shipping by the supplier. ILC incoming receiving inspection verifies that the materials received are as identified in the procurement documents, that no damage has occurred during shipment and that supplier certifications have been received which provide traceability information.

The following MIP's are performed for visual inspection of sewn seams during the glove restraint manufacturing process to assure that this particular failure cause is precluded from the fabricated item.

During PDA, the following inspection points are performed at the glove assembly level in accordance with ILC Document 0111-70028 (4000 glove) or 0111-710112 (Phase VI glove):

1. Visual inspection for fabric or material degradation.
2. Visual inspection for damage following proof pressure test and restraint loading.

D. Failure History -

B-EMU-106-A022 (8/13/90) - Broken 4000 Series right glove restraint fibers above top right corner of bartack under palm side gimbal ring. Damage occurred during glove handling and processing. Added caution note to FEMU-R-001 glove restraint material visual inspection under gimbal ring to preclude accidental overload of the bartack in the axial direction.

B-EMU-106-A029 (5/10/92) - Left glove restraint S/N 012 exhibited a hole on the back of the smallest finger. The damage was most likely caused by a sharp object during removal of the TMG-to-restraint stitching. No Corrective Action was taken.

B-EMU-106-T001 (3/13/92) - Left glove restraint exhibited seam separation in the thumb crotch caused by incorrectly installing the finger sizing cord terminators

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		106FM02		<p>too high on the thumb seams. The mispositioned terminators caused the finger sizing cord to double back on itself after exiting the tunnel and exert a load on the thumb tunnel which ripped the stitching. ECO 921-0045-2 adds an approved field procedure to the Maintenance Manual for removal/reinstallation of the sizing cord terminators.</p> <p>I-EMU-106--007 (4/9/92) - Inspection of right WETF glove restraint fabric revealed several openings caused by abrasion/general-wearout due to extensive cycling, accelerated by the WETF environment. This WETF glove had 396 manned pressurized hours of use (Spec: 461 hours). The estimated maximum pressurized time flight gloves will accumulate is 160 hours over their 8 year life. Therefore, no Corrective Action was taken.</p> <p>B-EMU-106-A041 (07/13/94) - The right and left restraints of glove assembly S/N 4032 exhibited frayed/broken yarns indicative of abrasion. The left restraint was cycled to the equivalent of 35 pressurized hours and the damage did not propagate. No corrective action was taken.</p> <p>I-EMU-106-A004 (08/19/96) - During WETF use, Glove Restraint developed a worn area from contact abrasion with the Gimbal Ring. Found Gimbal Ring surface finish was 125 RMS vs. spec of 32 RMS. Class I Gloves to be inspected per YTN 1220 for Gimbal Ring surface finish. Any rings that exceed 32 RMS will be replaced.</p> <p>Phase VI: J-EMU-106-019 (3/5/99)- The glove restraint failed (seam separation) at the outboard index finger metacarpal seam of the right Noriega Phase VI glove. Restraint fabric material had combed out from the stitching and individual yarns of material were frayed. Per CCBD H6954 design change, edgelocking has been incorporated into the glove restraint design. Outboard knuckle panel seam pleats have been eliminated. All glove hand seams will be coated with a polyurethane adhesive in the seam allowance area. Effective for flights STS-101 and subsequent (including STS-92, 97, 98, and 100).</p> <p>I-EMU-106-C024 (10/18/99) - Unacceptable windowing and seam wear at base of index finger of left glove restraint. Seam allowance showed signs of abrasion. Yarns pulled out of seam stitching. Root cause is design limitation. Phase VI glove restraint to be life limited to 198 hours of MPT.</p> <p>J-EMU-106-A008 (3/19/01) - During STS-100 pre-flight visual inspection, abrasion was noticed on Teflon abrasion patch behind middle primary axial restraint. Abrasion due to sharp hot-knifed edge of restraint webbing. Work instructions revised to inspect and rework sharp hot-knifed edges.</p> <p>B-EMU-106-A056 (9/12/01) - Pre-flight processing of S/N 6110 for STS-108 revealed a 1/8" cut in restraint fabric on inside of left glove below lower gimbal sheath seam. Cut caused by inadvertent hot knife contact. Restraints deliberately cut to 9/32" passed leakage and structural testing. All flight glove restraints are inspected prior to flight per FEMU-R-001. No corrective action required.</p>

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		106FM02		<p>4000/Phase VI: During ground turnaround, in accordance with FEMU-R-001, the glove assembly is visually inspected (pressurized and unpressurized) with the TMG removed for material damage or degradation. Additionally, a crewperson fit check (pressurized) is required prior to flight to verify fit. Also, glove and EMU level structural and leakage tests are performed.</p> <p>Every 56 hours of manned pressurized time on the 4000, the glove restraint and bladder assembly is removed from the disconnect and subjected to a visual inspection (interior and exterior surfaces) to the extent possible for structural integrity, material degradation or damage.</p> <p>F. Operational Use - 4000/Phase VI: Crew Response - Pre/Post-EVA: If during airlock operations, repress airlock. Consider use of backup gloves. EVA: When CWS data confirms SOP activation, abort EVA. Special Training - Standard training covers this failure mode. Operational Considerations - Flight rule A15.1.2-2 of "Space Shuttle Operational Flight Rules", NSTS-12820 defines go/no go criteria related to EMU pressure integrity. Generic EVA Checklist, JSC-48023, procedures Section 3 (EMU Checkout) and 4 (EVA prep) verify hardware integrity and systems operational status prior to EVA. Real Time Data System allows ground monitoring of EMU systems.</p>

EXTRAVEHICULAR MOBILITY UNIT
SYSTEMS SAFETY REVIEW PANEL REVIEW
FOR THE
I-106 GLOVE ASSEMBLY
CRITICAL ITEM LIST (CIL)

EMU CONTRACT NO. NAS 9-97150

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